YAKEEN

Lecture - 10

Some Basic Concept of Chemistry

By

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CHEMISTRY

TODAY'S GOAL

- DILUTION EQUATION ✓
- ✓ MOLARITY OF MIXTURES OF SOLUTIONS
- ✓ PARTS PER MILLION (PPM)
- ✓ EQUIVALENT MASS
- LAW OF EQUIVALENCE → Next Class

How many grams of 70% (w/w) concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? [NEET 2013]

(a) 54.0 g conc. HNO_3
(b) 45.0 g conc. HNO_3
(c) 90.0 g conc. HNO_3
(d) 70.0 g conc. HNO_3

A: 70g of solute (HNO_3) is present in 100g of Conc. HNO_3

$HNO_3 \rightarrow$ $M = 2M$

$V = 250 ml$

$M_B = 63 g$

$$M = \frac{W_B \times 1000}{M_B \times \text{Vol of sol}^n \text{ (ml)}}$$

$$2 = \frac{W_B \times \cancel{1000}^{4}}{63 \times \cancel{250}}$$

$$\frac{\cancel{126}^{63}}{\cancel{4}_{2}} = W_B \Rightarrow \boxed{W_B = 31 \cdot 5 g}$$

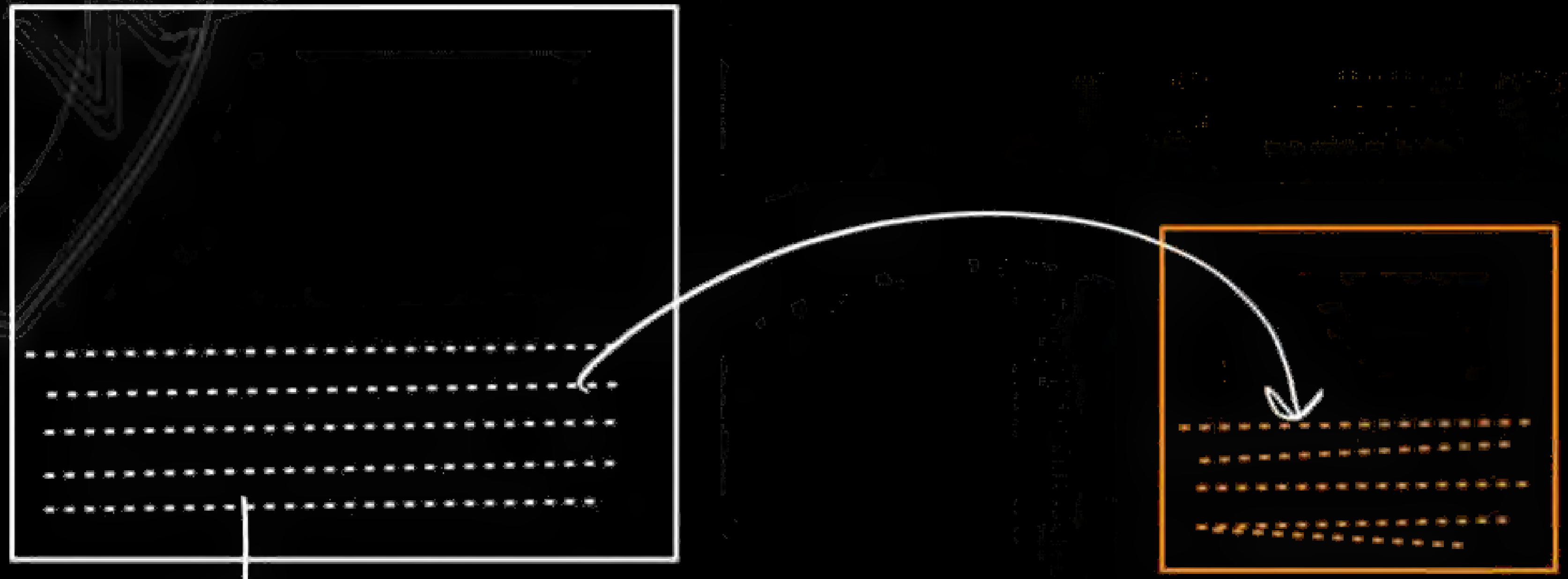
70 g of HNO_3 is present in Conc. HNO_3 = 100g.

31.5 g of HNO_3 is present in Conc. HNO_3

$$= \frac{100}{70} \times 31.5$$

$= 45$ g of Conc. HNO_3

Dilution Equation



Conc. HCl

12 M

moles of solute before dilution = moles of solute after dilution

$$M_1 V_1 = M_2 V_2$$

M_1 = Molarity Conc. solution

V_1 = Vol. of Conc. solution

V_2 = Vol. of dilute solution

M_2 = Molarity of dilute solution

$$M = \frac{n}{V(L)}$$

$$n = M \times V(L)$$

Q What Volume of 12 M HCl is required to prepare 500 ml of 3 M HCl?

$\downarrow M = \frac{n}{V} \uparrow$

Ans

$M_1 = 12\,M$

$V_1 = ?$

$V_2 = 500\,ml$

$M_2 = 3\,M$

$M_1 V_1 = M_2 V_2$

$\overset{4}{\cancel{12}} \times V_1 = \cancel{3} \times 500$

$$\boxed{V_1 = \frac{500}{4} = 125\,ml}$$

Concentrated aqueous solution of sulphuric acid 98 % H_2SO_4 by mass and has a density of 1.80 g mL^{-1}. Volume of acid required to make 1 litre of 0.1M H_2SO_4 solution is: [AIPMT 2007]

(a) 11.10 mL
(b) 16.65 mL
(c) 22.20 mL
(d) 5.55 mL ✓

$M_B = 98g$

Ans

Conc. H_2SO_4

98% H_2SO_4 by mass

d of soln = 1.8 g/ml

$V_1 = ?$

$V_2 = 1L = 1000 ml$

$M_2 = 0.1 M$

$M_1 = \frac{\cancel{98} \times 1.8 \times 10}{\cancel{98}} = 18 M$

$$M_1 V_1 = M_2 V_2$$

$$18 \times V_1 = 0.1 \times 1000$$

$$V_1 = \frac{100}{18} = 5.55\ ml$$

Molarity of Mixtures

→ same nature
same substance

HCl + HCl = HCl

$n_1 + n_2 = n_3$

$n = M \times V(L)$

$M_1V_1 + M_2V_2 = M_3V_3 \quad (V_3 = V_1 + V_2)$

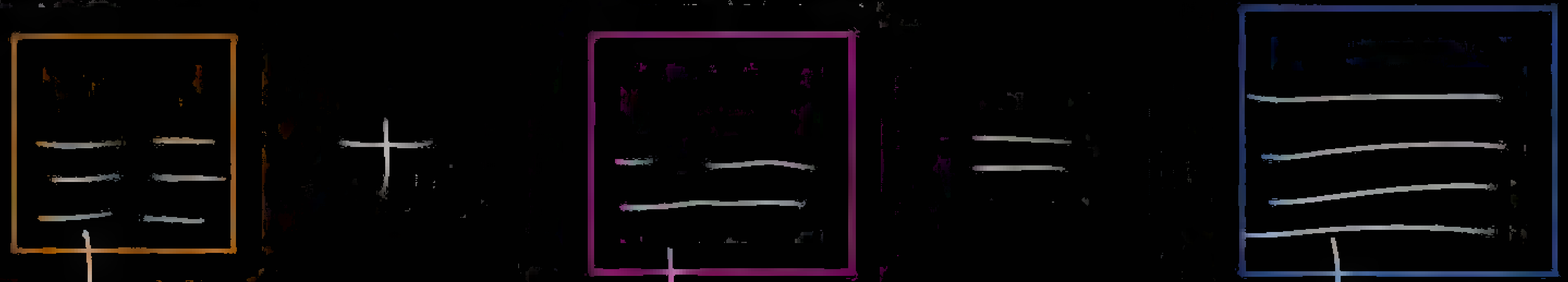
$$\boxed{\underline{M_3} = \frac{M_1V_1 + M_2V_2}{V_3}} \quad (V_3 = V_1 + V_2)$$

Same substances added

Two solutions of a non-electrolyte are mixed in the following manner:
480 mL of 1.5 M first solution +520 mL of 1.2 M second solution. What is the molarity of the final mixture? [AIIMS 2011]

(a) 2.70 M
(b) 1.344 M
(c) 1.50 M
(d) 1.20 M

As



$V_1 = 480\,ml$
$M_1 = 1.5\,M$

$V_2 = 520\,ml$
$M_2 = 1.2\,M$

$M_3 = ?$
$V_3 = V_1 + V_2$

$$M_3 = \frac{M_1V_1 + M_2V_2}{V_3}$$

$$\left(\begin{array}{l} V_3 = V_1 + V_2 \\ V_3 = 480 + 520 \\ V_3 = 1000 \end{array} \right)$$

$$M_3 = \frac{15 \times 480 + 12 \times 520}{1000}$$

$$\begin{array}{r} 720 \\ 624 \\ \hline 1344 \end{array}$$

$$M_3 = \frac{\frac{3}{\cancel{2}} \times \overset{240}{\cancel{480}} + \frac{12}{1\cancel{0}} \times 52\cancel{0}}{1000}$$

$$\boxed{M_3 = \frac{1344}{1000} = 1.344\,M}$$

The volume of water that must be added to a mixture of 250 ml of 0.6 M HCl and 750 ml of 0.2 M HCl to obtain 0.25 M solution of HCl is :

(a) 750 ml
(b) 100 ml
(c) 200 ml
(d) 300 ml

Ans

Water

$V_1 = 250\text{ ml}$
$M_1 = 0.6\text{ M}$

$+$

$V_2 = 750\text{ ml}$
$M_2 = 0.2\text{ M}$

$=$

$M_3 = 0.25\text{ M}$
$V_3 = a\text{ ml}$

$$M_3 V_3 = M_1 V_1 + M_2 V_2$$

$$M_3 = \frac{\underline{0.6 \times 25\cancel{0}} + 0.2 \times 75\cancel{0}}{a}$$

$$M_3 = \frac{300}{a} = 0.25$$

$$\frac{300 \times \overset{4}{\cancel{100}}}{0.25} = a \Rightarrow \boxed{a\,ml = 1200\,ml}$$

Total Valume = 1200ml

Vol of water adddd = 1200 - 750 - 250

= 200ml

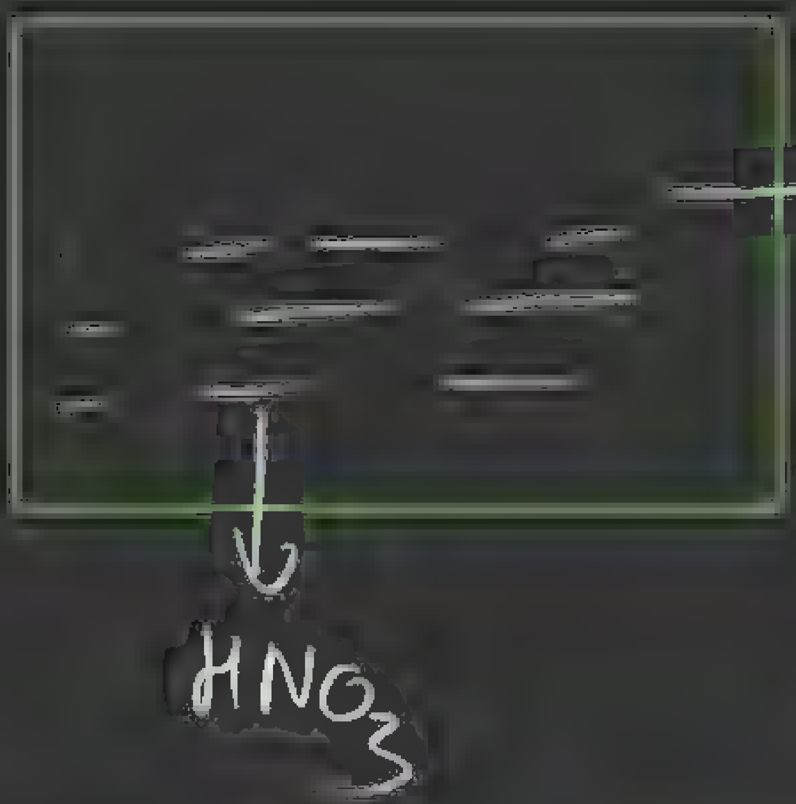
Parts per million (ppm)

10 ppm by mass of HCl

10 g of solute (HCl) is present in 10^6 g of solution

80 ppt by mass (w/w) of HCl (solute)

80 g of solute is present in 1000 g of solution



25 ppm by Volume (V/V)

25 ml of solute (HNO_3) is present in 10^6 ml of solution

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32 ppm by strength (w/V)

32g of solute (NaOH) is present in 10^6 ml of solution

$$\underline{ppm} = \frac{\text{parts of solute}}{\text{parts of solution}} \times 10^6$$

Q A sample of drinking water has 15 ppm of $CHCl_3$ by mass

(Molar mass of $CHCl_3$ = 119.5 g)

(a) express this in %age by mass

(b) also find molality of solution

→ $CHCl_3$ 15 ppm by mass

(a) $\% age$ of $CHCl_3$ = $\frac{\text{mass of } CHCl_3}{\text{mass of solution}} \times 100$

$\boxed{15 \text{ ppm of } CHCl_3 \text{ by mass}}$

15 g of $CHCl_3$ present in 10^6 g of solution

$\% age$ of $CHCl_3 = \frac{15}{10^6} \times 100$

$\% age$ of $CHCl_3 = 15 \times 10^{-4}$

(b) $m = \dfrac{W_B \times 1000}{M_B \times W_A (\text{kg})}$

$W_B = 15\,g$

$M_B = 119.5\,g$

$W_A \approx 10^6\,g$

$m = \dfrac{15 \times 1000}{119.5 \times 10^6}$

$$\boxed{m = \frac{15}{119.5} \times 10^{-3}}$$

Equivalent mass

mass of substance which will react or produce or displace

1g of Hydrogen or 8g of Oxygen or 35.5g of Chlorine or 23g of Na or 17g of OH or 30g of CO_3^{2-}

or ________ g of Ca

$$\underline{1}\,C + \underline{2}\,H_2 \longrightarrow \underline{1}\,CH_4$$

1 mole of C

12 g of C

2 moles of H_2

4 g of H_2

1 mole of CH_4

16 g of CH_4

1 mole has mass = Molar mass

$^{1}_{1}H$

$M_{H_2} = \underline{2\,g}$

4 g of H_2 react with C = 12 g

1 g of H_2 react with C = $\frac{12}{4}$ = 3 g is eq mass of C in the rxn

4g of H_2 ⟶ 16g CH_4

1g ⟶ $\frac{16}{4}$ = 4g is eq mass of CH_4 in this rxn

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

1 mole 3 mole 2 moles

28g ⟵ 6g ⟶ 34g

$M_{H_2} = 2g$

$M_{N_2} = 2 \times 14$

$M_{NH_3} = 17g$

$6g\ H_2 \longrightarrow 28g$ of N_2

$1g\ H_2 \longrightarrow \boxed{\frac{28}{6}\ g \text{ of } N_2}$

eq mass of N_2 in this n^r

$6g\ H_2 \longrightarrow 34g\ NH_3$

$1g\ H_2 \longrightarrow \frac{34}{6} = \frac{17}{3}\ g$ of NH_3

✓ $\frac{17}{3}\ g$ is eq mass of NH_3 in the n^n

$$1C + \frac{1}{2}O_2 \longrightarrow 1CO$$

1 mole $\quad \frac{1}{2}$ mole $\quad$ 1 mole

$$12g \longleftarrow 16g \longrightarrow 28g$$

$$\cancel{8} \times \frac{12}{\cancel{16}_{2}} \longleftarrow 8g \longrightarrow \frac{28 \times \cancel{8}}{\cancel{16}_{2}}$$

6g is eq mass of C in this rxn

= 14g is eq mass of CO in this rxn

$M_C = 12g$

$M_{O_2} = 32g$

$M_{CO} = 28g$

$$\boxed{\text{eq mass or eq weight} = \frac{\text{Molar mass}}{n_{\text{factor}} \text{ or Valency factor}}}$$

Find n-factor or valence factor for different substance

For acids n-factor = Basicity

Basicity = no of H^+ ions given by 1 molecule of acid

$1H_3O^+$ or

$$\underline{1}HCl + 1H_2O \longrightarrow \underline{1H^+} + 1Cl^-$$

$n_f = 1$

$$\text{eq mass of HCl} = \frac{M_{HCl}}{n_{factor}} = \frac{36.5}{1} = 36.5g$$

$\underline{H_2SO_4} + H_2O \longrightarrow \underline{2H^+} + 1\,SO_4^{2-}$

n factor of $H_2SO_4 = 2$

Eq. mass of $H_2SO_4 = \frac{98}{2} = 49\,g$

Protic acid → substance which gives it's H^+ in water

Acids	n-factor
HCl, HNO_3, H_3PO_2, H_3BO_3 or $B(OH)_3$	1
H_2SO_4, H_3PO_3	2
H_3PO_4	3

$\boxed{H_3PO_2,\ H_3PO_3,\ H_3PO_4}$

$\downarrow$

n_f = no. of oxygen atoms $- 1$

H_3BO_3 (Boric acid)

or $B(OH)_3$

$B(OH)_3 + H_2O \longrightarrow B(OH)_4^- + H^+$

Boric acid is not a protic acid

$n_f = 1$

For Bases n-factor = Acidity

Acidity = no of OH^- given by 1 molecule of Base

$$\underbrace{NaOH}_{n_f = 1} + H_2O \longrightarrow 1Na^+ + 1OH^-$$

$$Ba(OH)_2 + H_2O \longrightarrow 1Ba^{2+} + 2OH^-$$

$n_f = 2$

Bases	n_f
NaOH, KOH	1
$Ba(OH)_2$	2
$Al(OH)_3$	3

For ions n-factor = |Charge on ion|

$CO_3^{2-} \Rightarrow n_f = |-2| = 2$

Eq mass of $CO_3^{2-} = \frac{60}{2} = 30g$

$OH^- \Rightarrow n_f = |-1| = 1$

Eq mass of $OH^- = \frac{17}{1} = 17g$

Al^{3+}

$\Downarrow$

$n_f = 3$

Eq mass of Al^{3+}

$= \frac{27}{3} = 9g$

For elements n-factor = | valency|

$Na \longrightarrow Na^+ + 1e^-$

$\downarrow$

$n_f = 1$

Eq. mass of Na
$= \frac{23}{1} = 23g$

$O + 2e^- \longrightarrow O^{2-}$

$n_f = 2$

Eq. mass of oxygen $= \frac{16}{2} = \frac{32}{4} = 8$

$H \longrightarrow H^+ + 1e^-$

$\downarrow$

$n_f = 1$

Eq. mass of Hydrogen
$= \frac{1}{1} = \frac{2}{2} = \frac{1}{1}$

$Cl + 1e^- \longrightarrow Cl^-$

$\downarrow$

$n_f = 1$

Eq. mass of Chlorine
$= 35.5g$

The equivalent weight of oxygen, when it is converted to oxide, is equal to [AIIMS 1995]

(a) $\frac{\text{Molecular weight}}{3}$

(b) Molecular weight

(c) $\frac{\text{Molecular weight}}{4}$

(d) $\frac{\text{Molecular weight}}{2}$

$$\text{eq. mass of } O_2 = \frac{\text{molecular weight}}{4}$$

For ionic compounds n-factor = |Charge on cation or anion|

$\overset{+}{Na}\overset{-1}{Cl} \longrightarrow n_f = 1$

$\overset{2+}{Ca}\overset{-1}{Cl_2} \longrightarrow n_f = 2$

$\overset{+2}{Ca}\overset{-2}{SO_4}$

$\downarrow$

$n_f = 2$

Eq. mass of $CaSO_4 = \frac{136}{2} = 68g$

Gram equivalents

gram equivalent (g eq) = $\dfrac{\text{mass (w)}}{\text{eq mass (E)}}$

Q find no of gram equivalents in 73 g of HCl?

As g eq = $\dfrac{\text{mass of HCl}}{\text{eq. mass of HCl}}$

$= \dfrac{73}{36.5} = 2$

HCl → $n_f = 1$

eq mass of HCl $= \dfrac{36.5}{1}$

Normality (N) – Number of gram equivalents of solute present in 1L of solution

$$N = \frac{\text{no. of g-eq. of solute}}{\text{Volume of solution (in L)}}$$

unit of N = geq/L
or Normal

$$\boxed{N = \frac{W_B \times 1000}{E_B \times \text{Vol. of solution (in ml)}}}$$

W_B = mass of solute

E_B = eq. mass of solute

Relation b/w Normality & Molarity

$$N = \frac{w_B \times 1000}{M_B \times \text{Vol of soln (ml)}} \times n_f$$

$$E_B = \frac{M_B}{n_f}$$

$$\boxed{N = M \times n_f}$$

Terms which do not depend upon Temp.

molality, mole-fraction, % by mass

better method to represent Concentration.

Terms which depend upon Temp.

Molarity, Normality, % age by Volume, % by strength

thanks
for watching